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ABSTRACT

Addressed to the health occupations education teacher, this guide is intended to provide appropriate information, viewpoints, and attitudes regarding the metric system and to make suggestions regarding presentation of the material in the classroom. An introductory section on teaching suggestions emphasizes the need for a "think metric" approach made up of hands-on experience with the use of convenient referents (models for some of the commonly used units) but very little conversion between the metric system and the customary system. Major contents are in eight chapters: (1) The System, (2) Length, (3) Area, (4) Volume (Cubic Measure and Liter Measure), (5) Mass, (6) Volume-Mass, (7) Other Units (Temperature, Force, Energy-Work, Power, Pressure-Stress, and Torque), and (8) Miscellaneous Exercises. Each chapter includes explanatory material and a variety of suggested learning activities, some with directions addressed to the student. Some activities and exercises are of a general nature and some are related to specific occupational areas: dental assisting, medical laboratory assisting, practical nursing, and pharmacy aide. A bibliography and answers to the exercises are appended. (JT)

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ED149170

METRIC IMPLEMENTATION GUIDE

IMPLEMENTING THE METRIC SYSTEM

IN

HEALTH OCCUPATIONS

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F O R E W O R D

This book is intended to guide vocational-technical educators in the implementation of the metric system in the classroom. It is not an official or complete presentation and discussion of the system. Indeed, only a small portion of the metric system is appropriate for discussion in this document and for vocational-technical instruction. Books and documents are available which do present the official position for the use of the metric system in its entirety.

Through the years there have been many systems of measure labeled "the metric system," so it is important to understand which such system is meant when the term "metric system" is used. The U. S. Metric Conversion Act of 1975 declared that the system to be followed was the International System of Units as established by the General Conference of Weights and Measures in 1960, otherwise known as SI (Systeme Internationale). It is the SI to which professional, industrial and educational associations, government and educational agencies, and business enterprises are now converting.

In most countries of the world some segment of the society has used a metric system. It is likely, however, that at least some elements of that system do not conform to the SI. For example, in this country, metric units have been used in the sciences and taught in science classes for years, but in large part this has been the cgs (centimeter, gram, second) system, whereas the SI is a mks (meter, kilogram, second) system. This means that the dyne and other units in the cgs system are not accepted for use in the SI. The quintal

(100 kilograms), used in Europe and some in the U. S., is metric but is not acceptable for use in the SI. The micron (0.001 millimeter) is another example of a metric unit which is not an SI unit. The U. S. Government has formed a committee to guide in the conversion from the traditional system to the SI but it may be some time before certain practices and policies are agreed upon and adopted large-scale in this country.

In this book attention is focused primarily on SI. Secondarily, attention is given to other metric units and customary units, and their relationship to SI.

ACKNOWLEDGMENTS

One of the functions of the Mathematics Department of Illinois State University is to engage in projects which will improve the effectiveness of elementary, secondary and post-secondary, and teacher education programs. Another function is to serve the citizens of the State of Illinois. Both functions are combined in the preparation of this Metric Implementation Guide, for the guide should ease the transition to the metric system (SI) of measurement for students and those employed in health related occupations.

Measurement is a mathematical topic, but its use in the health related occupations is best known by practitioners and educators in that field. The authors are deeply grateful to Carol Farran, RN; Pat Goeppner, RN; Vickie Lannie, RN; Randy Markward, RPh; John Maloney, MD; Gillian Renslow, RN; and Daniel Swanson for their assistance in gathering information for publication. Sincere thanks are extended to Sister Anthony, RN; Paula Garrott, BS, MT; Pat Goeppner, RN; Julie Larson, RN; Daniel Milligan, DDS; Dorcas Retzer, RN; Mary Lou Shea, RN; and Lorraine Summers, RN for their helpful examination of drafts of this guide.

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IMPLEMENTING THE METRIC SYSTEM IN HEALTH OCCUPATIONS

Measurement practices in health occupations are varied--more so than in many other occupations. Measurements in health occupations are taken using a form of the metric system for some pharmaceuticals, using the apothecaries' system for others, and using the English system for other measures, especially those of length and weight. Currently, some doctors, particularly younger ones, are giving prescriptions in metric which nurses and pharmacists must prepare using pharmaceuticals often measured in the apothecaries' system. Dentists use instruments which have one dimension measured in the metric system and another dimension measured in the English system. In a supply catalog, a dental preparation may be offered in liquid form by cubic centimeters and in powder form by ounces. Hospitals express the desire to go completely metric, but suppliers' catalogs list hospital supplies and equipment in English units.

The shift to metric measurement in the health occupations is progressing. More and more health occupation personnel are thinking metric, becoming less inclined to endure the bother of computations involving other measurement systems, and instead, are converting measures in the other systems to the metric system before making such computations. Pharmaceuticals are being labeled in both the metric and apothecaries' units, and in many instances the metric unit is given first.

The impact of the changeover to the metric system will soon be felt throughout the health occupations. It is therefore appropriate and important to prepare all students for this development now.

Teaching Suggestions

The primary goal in teaching the metric system is--think metric. All of the activities and instructional procedures should be designed with that goal in mind. Teaching activities which are primarily lecture or teacher-focused, therefore, are inadvisable. Activities which emphasize measuring, estimating and thinking in the system are far more valuable. Filmstrips and overhead transparencies, commercially produced or otherwise, are of limited value. In fact, few, if any, of these filmstrips and transparency packets are without serious error and most are quite expensive. Worse, however, is that the use of these materials is deficient in the same way that lectures are deficient--the student is only a passive participant.

Hands-on Experience

The main emphasis of instruction should be on experiences in actually measuring, estimating and thinking metric. For example, after students become acquainted with the meter and its subunits (particularly, dm, cm, and mm) they might use a meter tape to answer such questions as the following:

How many meters long is the room?

The window pane is how many centimeters wide?

What are the centimeter dimensions of the face plate on a light switch?

Unsharpened pencil lead is how many millimeters thick?

For some initial measurement activities both the object to be measured and the unit to be used should be selected by the teacher. Measurements should be reported to the nearest <u>whole</u> unit.

After some time has been spent with these measurement activities, activities in estimating lengths of various objects should be provided. The

objects to be measured and the units to be used should be varied. The emphasis should be "estimate, then check by measuring." Care should be taken to avoid precise measurements in checking. The goal is not great skill in estimating and measuring; the goal is to think metric--internalize the units.

Convenient Referents

Students should look for convenient models for some of the commonly used units. It might be, for example, that the width of the nail on their little finger is about 1 cm, the distance across the back of their hand 1 dm, or the top of their hipbone about 1 m above floor level. Objects commonly carried in pocket or purse may provide convenient models.

The purpose of such an approach is to promote thinking metric on the part of students who have grown up learning to think in and use the English system and who must now, in a short period of time, change and begin to think metric. Precise measurements and accurate estimates are not especially important. What is important is that the students quickly build in a set of referents which will thus enable them to make judgments about measurements of other objects as well as internalize the metric system. This approach should be applied to the teaching of area, volume, mass, and weight as well.

Little Conversion

Conversions between the metric system and the customary and apothecaries' systems should be avoided while learning the metric system. Conversions between systems can be made, when necessary, by simply consulting a table of equivalents readily available and doing the necessary multiplication or division. This is something which needs little instruction. It is appropriate, however, to make a few rough basic comparisons such as between the meter and the yard, the liter and the quart, and so on.

Conversions within the metric system, on the other hand, are quite a different matter. Converting from one metric unit to another is easily done by simply multiplying or dividing by a power of 10; a very simple task compared to converting in the customary system. Perhaps because it is so easy there is a tendency for teachers to overemphasize this activity. Some practice with conversions in the metric system is appropriate but practicing mechanical shortcuts is of questionable value. Instead, it seems more appropriate and beneficial to reason from the basic relationships between the units. Consider the following:

a. 750 grams = _____ kilogram(s)

The reasoning could be:

We have 750 grams and it takes 1000 grams to make a kilogram, so we have only 0.750 kilogram.

b. How many milliliters does a 3-liter container hold?

The reasoning might be:

The container holds 3 liters, and since 1 liter is 1000 milliliters the container holds 3000 milliliters.

Use of This Guide

This guide is addressed to the teacher. Its aim is to provide appropriate information, viewpoints, and attitudes regarding the metric system and to make suggestions regarding the presentation of the material in the classroom. A variety of activities is given and directions for some of these are addressed to the student. Nevertheless, this is not intended to be a workbook for students, nor is it intended that the activities given are sufficient or comprehensive. The attempt has been to provide examples of suitable activities designed to help the students think metric.

Several types of activities are suggested in each section. Each of these types makes a unique contribution to the learning process. It is appropriate, then, that some of each type should be provided for the student as each section is developed.

I. Measure

e.g., p. 13, exercise 1

II. Estimate and Measure

e.g., p. 23, exercise 2

III. Reasonable ("ball park") Estimates

The diameter of an aspirin tablet is _____.

(a) 3 m (b) 1 cm (c) 15 mm

IV. Metric Conversion Drill

1450 g = _____ kg

V. Applications

This guide is addressed to health related occupational programs including Dental Assisting, Medical Laboratory Assisting, Practical Nursing, and Pharmacy Aide. Some of the activities and exercises included are of a general nature

and some are related to specific occupations. It is intended that the teacher will select from the items suggested those which are appropriate to the group of students involved and it is expected that those suggested will stimulate the creation of additional or more appropriate items by the teacher.

It must be emphasized again that the actual measurements of some of the objects given are not important. What is important is that the students have the opportunity to actively estimate and measure many objects with which they are frequently associated; that they be encouraged to "think metric."

The System

The metric system had its beginning in the latter part of the 18th century when a group of French scientists, commissioned by their government, developed a system of measurement units. The system was officially adopted by the French government in 1795, and in 1840 its use was made mandatory by the government. Over the years most of the countries of the world have adopted it, including the United States. In 1866 the U. S. Congress passed an act making it legal, but not mandatory, to use the metric system in the United States. The Eleventh General Conference on Weights and Measures, meeting in 1960, adopted the International System of Units (SI)--the universally recognized metric system today. In December, 1975, HR 8674 was signed into law by President Ford, a bill that provides for the establishment of a 17-member metric board that will coordinate the conversion to the SI in the U. S. on a voluntary basis.

The SI is a modernized metric system of measurement with features which make it superior to the U. S. customary system and to other metric systems. One feature is that the base of the system is absolute; that is, force is not defined by action of gravity. An absolute system makes for simplicity of calculation. In SI units, a force of one newton gives a mass of one kilogram an acceleration of one meter per second per second. By contrast, in the European system, a force of one kilogram-force accelerates a mass of one kilogram 9.806 650 meters per second per second, and in the U. S. customary system, one pound force accelerates a mass of one slug 32.174 feet per second per second. Another feature is coherence. In a coherent system any derived unit is related to any other, or to the base units, without the use of conversion factors. A third feature is that only one unit is used for each physical quantity. By

contrast, the customary system has nine commonly used units for area, 25 units for energy, and 26 units for length.

The SI consists of seven base units, two supplementary units, and derived units, some of which have been given special names.

Base Units

Unit	Quantity	SI Symbol
meter	length	m
kilogram	mass	kg
kelvin	temperature	K
ampere	electric current	A
mole	molecular substance	mol
second	time	s
candela	light intensity	cd

The derived units are determined by multiplying or dividing base units, without using numerical factors other than one. Some of these are shown below. For a more complete listing of these units see Appendix A or a source from Appendix D.

Some Derived Units Without Special Names

Unit	Quantity	Formula
square meter	area	m^2
cubic meter	volume	m^3
meter per second	linear velocity	m/s
kilogram per cubic meter	density	kg/m^3

Some Derived Units With Special Names

Unit	Quantity	SI Symbol	Formula
newton	force	N	$m \cdot kg \cdot s^{-2}$
pascal	pressure	Pa	N/m^2
watt	power	W	J/s
joule	energy	J	N·m
coulomb	electric charge	C	A·s
volt	electric potential	V	W/A
hertz	frequency	Hz	1/s or s^{-1}
ohm	electric resistance	Ω	V/A
farad	electric capacitance	F	C/V

Multiples and submultiples of these units are expressed by means of certain prefixes.* Some of the prefixes are:

Prefix	Meaning	SI Symbol
mega	1 000 000	M
kilo	1 000	k
hecto	100	h
deka	10	da
deci	0.1	d
centi	0.01	c
milli	0.001	m
micro	0.000 001	μ

*For a more complete listing of the prefixes, see Appendix A.

The prefixes have decimal meanings, i.e., each is a power of ten, and conversions among the units is facilitated by a knowledge of our numeration system.

Examples

1 hectogram	= 100 grams	(1 hg = 100 g)
1 centimeter	= 0.01 meter	(1 cm = 0.01 m)
1000 grams	= 1 kilogram	(1000 g = 1 kg)
1 meter	= 10 decimeters	(1 m = 10 dm)
1 deciliter	= 0.1 liter	(1 dL = 0.1 L)*

Not all the prefixes will be used in actual practice. Note that the SI symbol for a unit is used for both the singular and plural forms. Other established conventions for spelling, usage, etc., include:

1. Symbols for unit names are written in lower case unless they are derived from proper names. Most SI symbols for unit names are single letters (for some exceptions see Appendix A).

   RIGHT: Contents 454 g
   WRONG: Contents 454 GM

2. Periods are not used after the symbols or prefixes unless a sentence ends with such.

   RIGHT: The pencil is 16 cm long.
   WRONG: The pencil is 16 cm. long.

3. A zero digit is used in the units place when naming a number less than 1.

   RIGHT: The distance to the next road is 0.8 km.
   WRONG: The distance to the next road is .8 km.

---

*The symbol for liter as prescribed in the SI is "ℓ". In December, 1976, however, the National Bureau of Standards stated that the capital letter "L" will be used instead in the U. S. This symbol has several advantages over the "ℓ" and has been urged for adoption in the SI.

4. Numerals containing more than four digits should be separated into groups of three digits in order to facilitate reading. No commas should be used in the spaces between groups of digits.

RIGHT: The distance from the earth to the moon is about 385 000 km.
WRONG: The distance from the earth to the moon is about 385,000 km.

RIGHT: A microgram is equal to 0.000 001 g.
WRONG: A microgram is equal to 0.000001 g.

5. Prefixes are not to be used without a unit.

RIGHT: The weight lifted was 186 kilograms.
WRONG: The weight lifted was 186 kilos.

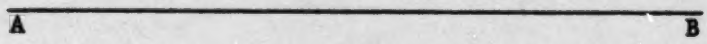
Additional information and discussion of the metric system may be found in a number of current sources (Appendix D).

Length

In the metric system (SI) the basic unit of length is the meter--probably the most familiar of the metric units. The meter is a little longer than the yard. Other metric units of length which are frequently used are:

kilometer--about 0.6 mile (or 7 city blocks) — 1 km = 1000 m

decimeter--the length of segment AB — 1 dm = 0.1 m



centimeter--the length of segment CD — 1 cm = 0.01 m

millimeter--the length of the segment to the right — 1 mm = 0.001 m

The centimeter has been used in the health occupations for some time. It is used in the operating room or in the emergency room to describe the length of incisions or lacerations. What will change most in the health occupations as the country shifts to the metric system is the use of metric units of length in some of the more commonplace activities involving measurements of room size, equipment size, bandage length and width, patient height, etc. In these measurement activities the meter, centimeter, decimeter, and millimeter will be most frequently used. The kilometer will not be used so much in the specific health occupations setting but will be used wherever the customary mile is used presently.

Suggested Activities*

1. Find several objects which have approximately the lengths in the chart below. Try to find things which you can easily remember or that you are frequently near. Include parts of your body such as palm, finger, distance from hip to floor, etc.

1 m	1 dm	1 cm	1 mm

*The activities suggested in this book are meant to include several areas in the health occupations. The teacher may select from these the activities most appropriate to the subject and students being taught.

2. Use the objects listed below and others from your school or home to practice linear measurement. The main objective is to develop a better "feel" for metric units of length, and therefore rough estimates and measures are adequate. Some objects you are near frequently; the measures of these and a few others (table height, for example) you will want to remember. More than one dimension of some objects may be estimated. Check your estimates by measuring.

Object	Estimated Length	Measured Length
Pane of glass		
Concrete block		
Lab table		
Note pad		
Your height		
Checkbook		
Floor tile		
IV pole		

The purpose in all these activities is to help foster "thinking metric." Accuracy in estimating is not crucial. Discourage students from measuring too precisely here.

3. Draw a line segment that has length

(a) 1 dm (b) 5 cm (c) 3 mm (d) 15 cm (e) 20 cm

Check by measuring. Try again with some other lengths until you are satisfied with your estimating skill.

A feel for metric units is important. Practice with estimating helps to think metric. Exercises such as the following also help. They will be of little value, however, if students do them by conversion. Instead, they should be done by just considering what is a reasonable answer. The measures given in exercises 4 and 5 and in similar exercises later in the unit are not important. Students may not know these measures nor do they need to in order to answer the questions. They should be able to rule out the inappropriate units or measures just by a general familiarity with the objects involved.

4. Supply the appropriate unit to make the sentence reasonable. Choose from mm, cm, dm, m, or km.

   a. The length of the hospital wing is 40 _____.

   b. Endotracheal tubes range in diameter from 5.0 _____ to 11.0 _____.

   c. A chrome, floor-standing garment rack is 17 _____ high.

   d. The metal forceps in the sterile suture kits are about 11 _____ long.

   e. The autoclave is 38 _____ wide.

   f. A Steri-strip closure is 3 _____ wide.

   g. The examining sheet is 1.5 _____ long.

   h. An average cavity preparation in a molar would be about 2-3 _____ wide.

5. Choose the best answer from those provided.

   a. A plastic cylinder _____ in length was placed around the coronary artery in order to narrow the vessel.

      (1) 2.5 mm (2) 5 dm (3) 25 cm

   b. The length of a newborn baby is _____.

      (1) 25 dm (2) 6 dm (3) 200 mm

   c. The average height of an adult female is approximately _____.

      (1) 1.4 m (2) 40 dm (3) 650 cm

d. A patient's sedimentation rate is determined by letting the blood set for an hour in a calibrated tube and noting how far the cells settle. A sedimentation rate of _____ per hour is a normal rate.

(1) 5 cm (2) 6 mm (3) 0.6 dm

e. The dentist's extraction forceps are _____ long.

(1) 1.75 dm (2) 175 cm (3) 0.4 m

Converting between metric measures is a needed skill. It is much easier than in the customary system (yards to inches, etc.), so there is some danger of overemphasizing this activity or of emphasizing mechanical procedures. Conversions among mm, cm, dm, m and km are all that are required. Knowledge of a few basic relations of a decimal nature is sufficient for this.

10 mm = 1 cm	10 dm = 1 m	1000 mm = 1 m
10 cm = 1 dm	1000 m = 1 km	100 cm = 1 m

For example, since 1 dm = 10 cm

8.6 dm = (8.6 x 10) cm = 86 cm

Likewise, since 1 dm = 100 mm

8.6 dm = (8.6 x 100) mm = 860 mm

6. Complete the following:

a. _____ mm = 56 dm

b. 56 dm = _____ m

c. _____ m = 3.2 km

d. 28 cm = _____ mm

e. 28 cm = _____ m

f. 8000 m = _____ km

g. 6 m 3 dm 5 cm = _____ m = _____ cm

h. 5 cm 8 mm = _____ cm = _____ m

For "fun":

i. _____ in. = 3 yd. 2 ft. 7 in.

j. 2 yd. 1 ft. 5 in. = _____ yd. = _____ in.

7. Elastic bandages are commonly 500 cm long and come in packages of 10. What is the total length of bandage, in meters, in one of these packages?

Area

Measuring area using metric units will occur with increasing frequency in health occupations. Some such measuring will be for commonplace purposes such as room size, etc. More crucially, however, area is sometimes used to more accurately prescribe medications. Particularly with children, skin area is used to determine the amount of medication needed in some cases. The initial activities here as elsewhere are designed to help think metric.

Suggested Activities

A unit of area convenient in many instances is the square centimeter: . "Square centimeter" is expressed with the symbol cm^2.

1. Make a model of a square centimeter from paper.
2. Use your model to estimate the area of each of these regions.

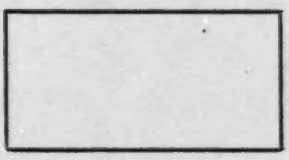


Figure 1

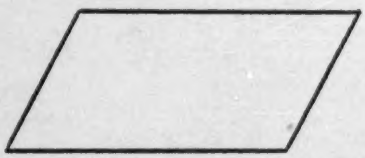


Figure 2

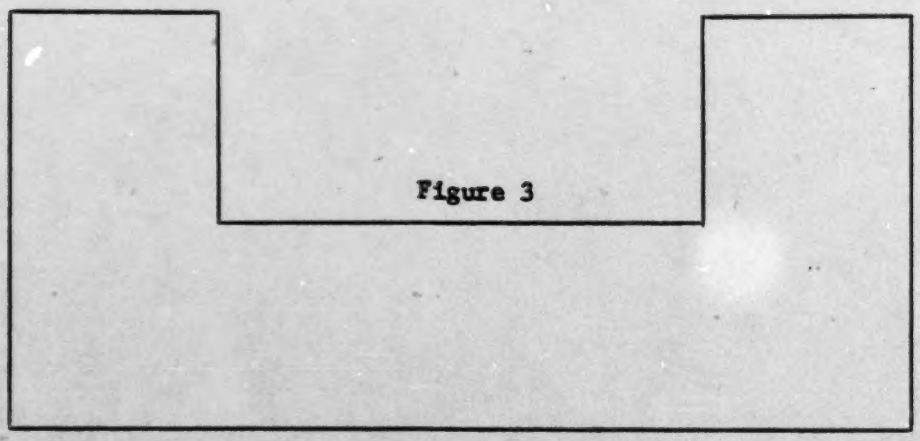


Figure 3

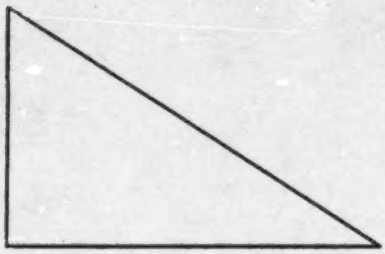


Figure 4

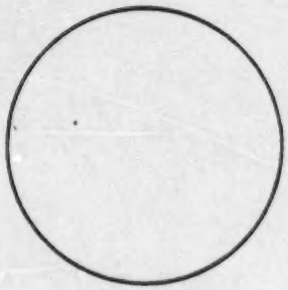


Figure 5

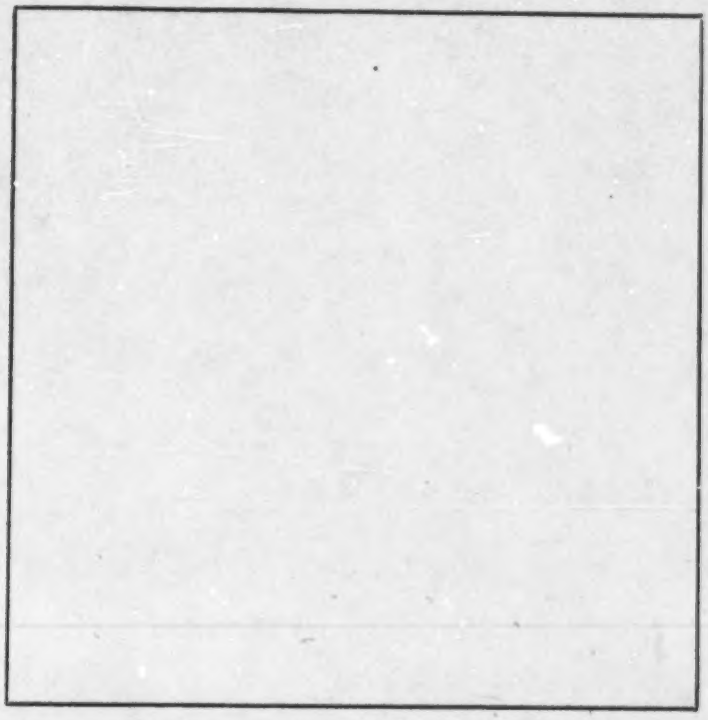
Region	Estimated Area
1	_____
2	_____
3	_____
4	_____
5	_____

The area of a rectangular region is, of course, computed by the formula $A = lw$. For example, a rectangle 2 m by 3 m has an area of 6 square meters (6 m^2); a rectangle 2 cm by 3 cm has an area of 6 cm^2; a large room 8 m by 10.5 m has an area of 84 m^2. Formulas for the area of a triangle and circle are $A = \frac{1}{2}ab$ and $A = \pi r^2$.

3. Check your estimates in number 2 by using your ruler to measure any segments needed to calculate the area.

Region	Calculated Area
1	_____
2	_____
3	_____
4	_____
5	_____

Another convenient unit of area is the square decimeter (dm^2).



4. Make a model of this square unit from heavy paper. Use your model as an aid to estimate the area of several objects. Check your estimate by measuring and calculating. Some objects are suggested. Include others from your room, home, or place of work.

Object	Estimated Area	Calculated Area
File cabinet		
Q towel		
Sterile drape		
Dri Clave Sterilizer		
Desk top		
Book cover		

5. A square meter is a rather large unit of area. What objects can you find in your classroom that have an area of approximately:

   a. 2 m^2 _____ _____

   b. 4 m^2 _____ _____

   c. 0.5 m^2 _____ _____

6. Supply the appropriate unit to make the sentence reasonable. Choose from cm^2, dm^2, or m^2.

   a. A tongue blade has an area of about 28 _____.

   b. This sheet of paper has an area of about 616 _____.

   c. The floor of the classroom is about 38.5 _____ in area.

   d. The bedside table has a top with an area of 27 _____.

   e. The area of a postage stamp is about 3 _____.

   f. The area of the micro slide is about 18 _____.

7. Calculate the area of these rectangular regions:

   a. 4 m x 5 m

   b. 6 cm x 8 cm

   c. 3.6 m x 8 m

   d. 27.5 m x 7.6 m

   e. 350 m x 500 m

   f. 285 m x 312 m

8. Using the given dimensions for a rectangular region find the area in cm^2.

   a. 4 m x 18.5 cm

   b. 2 m x 3 m

   c. 2.5 m x 4.2 cm

   d. 22 cm x 28 cm

   Find the area in m^2.

   e. 420 cm x 5 m

   f. 118 cm x 25 cm

   g. 65 cm x 6.25 m

   h. 0.5 m x 120 m

A square 100 cm on each side is the same size as a square 1 m on each side. Such a square would contain 100 rows of 100 cm^2 each. Consequently $1\ m^2 = 10\ 000\ cm^2$.

9. Complete the following:

   a. $3\ m^2 =$ _____ cm^2

   b. _____ $m^2 = 5000\ cm^2$

   c. $5\ dm^2 =$ _____ cm^2

   d. $250\ cm^2 =$ _____ dm^2

   e. $40\ 000\ cm^2 =$ _____ m^2

10. A table top 120 cm by 300 cm has an area of 36 000 cm^2 or _____ m^2.

11. A physiotherapy table has an area of about 1.12 m^2 or _____ cm^2 or _____ dm^2.

12. There are 5 shelves in a metal storage cabinet each 6 dm wide and 9 dm long. The total storage area of these shelves is 270 dm^2 or _____ m^2.

13. It is recommended that each hospital patient be provided with a minimum of 743 square decimeters of floor space. What is the minimum number of square meters of floor space needed for a two-bed room?

Volume

The concept of volume arises frequently in the health occupations. In the customary (Imperial) system many different units are used--bushel, peck, quart, gallon, ounce, teaspoon, tablespoon, cup--some for dry measure, some for liquid measure. Cubic units such as the cubic inch and cubic foot, etc., are also used to express volume. For pharmaceuticals, the apothecaries' system has been used to express amounts such as minims and fluid drams. In the metric system, however, there are only two ways to express volume; in cubic units and in liters.

Cubic Measure

The cubic meter (m^3), cubic decimeter (dm^3) and cubic centimeter (cm^3) will be the commonly used cubic units. The cubic centimeter has long been used to express the size of injections or samples. The abbreviation cc. is commonly used in such cases but correct SI form dictates that the symbol cm^3 be used. The cubic meter and cubic decimeter have been as seldom used in health occupations as in other occupations. Ultimately, however, the cubic meter will be used to describe such things as the volume of rooms or buildings. The cubic decimeter may not be used often but it plays an important role in relationships among other metric units which will be discussed later. Another unit sometimes used in laboratory analysis reports is the cubic micron and symbolized μ^3. The micron, a unit which is equivalent to 0.000 001 meter, has been excluded from use in the SI.

The volume of a rectangular solid is given by the formula $V = lwh$. The volume of a cylinder is $V = \pi r^2 h$. In these cases and in others where the volume can be computed by formula, cubic units will be used to express the volume. In many other cases the liter (discussed later) will be used.

Suggested Activities

1. a. Make a model of a cubic centimeter and cubic decimeter out of heavy paper. A suggested diagram is given in Appendix C. (Metal or wood is suitable, also.)

   b. Make a model of a cubic meter using meter sticks or similar material for edges.

   c. Challenge. Make a model of a cubic millimeter.

2. Estimate the volume of several objects in the room by thinking of cubic units—m^3, dm^3, or cm^3. Check your estimates by measuring with the cubic unit or a tape. Some objects are suggested. Include others from your room, home, or place of work.

Object	Estimated Volume	Calculated Volume
Teacher's desk		
Chalkboard eraser		
File cabinet		
Space under a bed		
Tray cabinet		
Bandage box		
Medicine cabinet		
Medicine box		
Bedside cabinet		

3. Supply the appropriate unit to make the sentence reasonable. Choose from mm^3, cm^3, dm^3, or m^3.

   a. The volume of an adhesive bandage box is about 21 _____.

   b. A Dri Clave Sterilizer has a volume of 24 _____.

   c. The volume of a germicide tray is 2.4 ____.

   d. A classroom would have a volume of 150 _____.

   e. The volume of a laundry cart is about 0.3 _____.

   f. A normal platelet count is 145 000 to 400 000 per _____.

   g. The volume of a dental injection is about 1.8 _____.

4. Remembering that it would take 1000 cm^3 blocks to occupy the space of one dm^3 and 1000 dm^3 blocks to make up one m^3, fill in the following blanks to make true sentences.

a. 2 m^3 = _____ dm^3

b. 500 cm^3 = _____ dm^3

c. 4000 cm^3 = _____ m^3

d. 4000 dm^3 = _____ m^3

e. 0.42 dm^3 = _____ cm^3

f. 1.491 m^3 = _____ dm^3

g. 0.1024 dm^3 = _____ cm^3

h. 186 321 cm^3 = _____ m^3

i. 144 dm^3 = _____ cm^3

j. 144 dm^3 = _____ m^3

5. Novocain comes in boxes of ten 30 cm^3 vials. Five boxes would contain _____ dm^3 of novocain.

6. A box that is 1 dm wide, 2 dm long and 1.5 dm high has a volume of _____.

a. 4.5 dm^3 b. 3000 cm^3 c. 4.5 mL

7. The number of cubic meters of space required for each patient in a hospital room is about 18. If a room measures 6 m by 4 m by 2.4 m, is it large enough for a "double room"?

8. A storage cabinet measures 100 cm by 50 cm by 30 cm. What is its volume in cubic meters? in cubic decimeters?

Liter Measure

The liter is not one of the basic SI units but it is a convenient unit and is used frequently enough that it has been accepted by SI. The liter is just a little larger than a quart and it probably will be used for small to moderately-sized amounts. Currently, some hospitals use the liter as equivalent to the quart and 500 mL as equivalent to the pint.

Present practice indicates that smaller amounts may be measured in milliliters in some instances and cubic centimeters in others. For example, vaccines or antibiotics may be prescribed in cm^3. Medicines administered orally

might be prescribed in milliliters. Some dosages are described by use of deciliters.

The preceding remarks reflect the fact that in the metric system we have two alternatives for describing measures of volume or capacity--cubic measure and liter measure. There is no set rule stipulating which of the two measures should be used in a given situation. It seems to be simply a matter of custom and convenience.

One of the nice features of the metric system is the ease with which one may change from one unit of measure to another. This pertains to the interchange between cubic measure and liter measure as well. A liter container holds exactly the same amount as a cube one decimeter (10 centimeters) on each edge. Consequently, a 10-liter pail has a volume of 10 cubic decimeters. A 2-liter milk carton would have a volume of 2 cubic decimeters; a 1000 liter tank has a volume of 1 cubic meter.

Since a cube 10 centimeters on each edge contains 1000 cubic centimeters, each of these cubes is 0.001 of a cubic decimeter and hence is 0.001 of a liter. That is, one cubic centimeter equals 1 milliliter. This explains why medicine dosages can be given in either milliliters or cubic centimeters. A dose of 20 cubic centimeters is equal to 20 milliliters.

The size of a milliliter can be related to the customary teaspoon by the fact that five milliliters = one teaspoon (approximately). The customary measuring cup used in cooking holds about 240 milliliters.

As with other metric units, it is important to develop a feel for the metric units of liter, deciliter, and milliliter. Classroom activities such as the following may help with this.

Suggested Activities

1. Estimate the capacity of each of these. Check your estimate by using water and a graduated cylinder to measure the capacities of small containers. Select some other containers familiar to you and learn their capacity.

Object	Estimated Size	Measured Size
Pop can	_____	_____
Thimble	_____	_____
Soup spoon	_____	_____
Dinner glass	_____	_____
Catsup bottle	_____	_____
Medicine bottle	_____	_____
Thermometer jar	_____	_____
Instrument tray	_____	_____
Wash basin	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

2. Supply the appropriate unit to make the sentence reasonable. Choose from liter (L), deciliter (dL), or milliliter (mL).

   a. The adult dosage for the phosphate enema is 130 _____.

   b. Normal human plasma is usually administered in 500 _____ amounts.

   c. The medicine cup has a capacity of 30 _____ and has graduations, in intervals of 5, from 5 _____ to 30 _____.

   d. A 3.5 _____ blood analyzer cup was used in the lab.

   e. The usual dose of terpin hydrate is 4 _____.

   f. Sodium chloride irrigation comes in 500 _____ bottles.

   g. Chocolate milk can be purchased in 2 _____ containers.

   h. The oxygen catheter delivered approximately 5 _____ of oxygen per minute.

   i. The vial was filled with 30 _____ of medicine.

   j. The volume of a gelatin capsule is about 3 _____.

   k. A 20 _____ blood specimen was obtained from each volunteer before the Hong Kong flu vaccine was injected.

   l. The average rate of salivation is about 35 _____ every 15 minutes.

3. Choose the best answer from those provided.

a. A sample of _____ blood was drawn for chemical analysis.

(1) 100 dL (2) 15 mL (3) 0.5 cm^3

b. The smallest size blood sample that is used for glucose analysis is 20 _____.

(1) µL (2) cm^3 (3) dL

c. A patient's cholesterol level is within the normal range if it is 200 mg/_____.

(1) L (2) dL (3) mL

The liter, milliliter, and deciliter are commonly used in health occupations. Conversions among them are simply done by remembering that:

1 mL = 0.001 L	1000 mL = 1 L
1 mL = 0.01 dL	10 mL = 1 dL
1 dL = 0.1 L	10 dL = 1 L

So, for example, 258 mL = 0.258 L.

4. Complete the following.

a. 1 liter = _____ mL

b. 2000 mL = _____ L

c. 0.5 L = _____ dL

d. 20 000 mL = _____ L

e. 0.25 L = _____ mL

f. 40 dL = _____ mL

g. A 10 liter bucket holds _____ mL.

h. A box which measures 10 cm on each edge has a volume of 1 _____.

i. At 4 °C one liter of distilled water weighs 1 kilogram. At that temperature _____ mL would weigh 1 gram.

j. A 2 liter container of lemonade will be adequate for eight _____ mL servings.

k. Fractional parts of a liter are expressed in decimal form. Thus 2½ liters would be written as 2.5 L which equals _____ mL.

5. It would take _____ mL of Lysol to make one liter of 10% Lysol solution.

6. You are to administer 200 000 units of penicillin and the vial contains 300 000 units per mL. How many mL should you give?

7. Make the following conversions between cubic units and liter measures.

a. 18 cm^3 = _____ mL

b. 5 dm^3 = _____ L

c. _____ cm^3 = 259 mL

d. 18 L = _____ dm^3

e. 1.5 L = _____ m^3

f. 0.3 dm^3 = _____ mL

g. A box 2 cm by 3.5 cm by 10 cm has a volume = _____ = _____ mL.

8. Household measures are not used for administration of drugs in the hospital but they are used in the home. A patient who is to take 15 mL of a certain medicine every four hours should take _____ teaspoons or _____ tablespoon(s) of the medicine for each dose.

9. Put 5 g of salt into a graduated glass measure containing 20 mL of water. Does the water level rise to the 25 mL mark? Does a gram of salt have a volume of 1 mL?

10. Mix 5 mL of alcohol with 20 mL of water. Does the mixture contain 25 mL? This finished solution is called a 20% alcohol solution (5/25 = 20%). How many mL of alcohol are needed to make 0.5 liter of a 20% alcohol solution?

11. A medicine is to be made by mixing 20 mg of a drug and 100 mL of water. If the average adult does of the medicine is to contain 2 mg of the drug, how many mL must be given for each dose?

Mass

In the health occupations the measurement of mass or weight is a commonplace activity. A few metric units of mass are already in use in the health occupations. Many pharmaceuticals are now measured in milligrams. Laboratory analysis reports use the microgram and the picogram. Use of units such as the gram and kilogram will continue to increase as more use is made of the metric system in determining the mass of patients, of equipment, and of other objects associated with health occupations.

The terms mass and weight and their use have had much recent discussion. Although mass is a quantity with an SI base unit and force is a quantity with an SI derived unit, the term weight does not appear in SI. In science and engineering a distinction between mass and weight has been maintained. Currently, practices are being implemented (see Guidelines for Writers of SI Metric Standards) which will mean that the term weight will not be used in science and other technical fields. Instead, the term force of gravity will be used. In general everyday use, including the health occupations, no harm will occur by using the terms weight and mass synonymously.

Several abbreviations for metric units are in current use which do not conform to SI style practices (see page 10). It is common to see the symbol gm, the abbreviation Gm., and other expressions for gram. The symbol g, however, is the proper SI symbol for gram. It is understandable that a carelessly handwritten "gm" might be mistaken for "gr" but it seems unlikely that any such confusion would occur when the symbol g is used. Furthermore, as the use of the metric system increases there will be less use of the abbreviation for grain.

The microgram (0.000 001 g) has been customarily abbreviated mcg., perhaps to avoid the duplication in use of the letter μ for micron. The micron is a metric unit commonly used in the past but is not accepted in the SI. Consequently, there is no reason for continuing the use of mcg. to denote the microgram. Instead, the proper SI symbol, μg, should be used.

The picogram (0.000 000 000 001 g) is a very small unit of mass used in hematology lab reports. It is sometimes symbolized on such reports as μμg. Such repetitious use of prefixes is not allowed in the SI, however. The proper symbol for picogram is pg. It is hoped that these traditional but incorrect symbols for metric units will soon disappear from publications and writing habits of those in the health occupations.

Suggested Activities

1. Supply the appropriate unit to make the sentence reasonable. Choose from kilogram (kg), gram (g), milligram (mg) and microgram (μg).
   a. The hearts of a group of patients who had severe angina pectoris ranged in mass from 320 _____ to 520 _____.
   b. A golf tee has a mass of 1 _____.
   c. The mass of a bottle of vitamins is 250 _____.
   d. A piece of paper this size □ has a mass of 1 _____.
   e. The patients who were allergic to penicillin were given 500 _____ of tetracycline hydrochloride four times a day.
   f. In the experiment the weanling rats were given a low dose of cortisone, 0.5 _____ per 60 _____ animal.
   g. Each cm^3 of a B-complex injectible contains 100 _____ of vitamin B_1.
   h. Metraminol is a drug that is used in the treatment of shock. In an emergency situation, 500 _____ to 5 mg may be injected intravenously.

2. A tablet that is taken for headaches is ergotamine with caffeine. Each tablet contains 1 mg of ergotamine tartarate and _____ of caffeine.

   (a) 5 g (b) 100 mg (c) 0.5 g

3. Estimate the mass of each of the following. Check your estimates by means of a balance or scale. Some objects you are near often; the masses of these and a few others (pencil, for example) you will want to remember.

Object	Estimated Mass	Measured Mass
Billfold		
Pencil		
Textbook		
Bottle		
Tumbler		
Towel clamp		
Ear syringe		
Suture needle		
Surgical tray		
Solution bowl		
Wash basin		
Instrument stand		
_____		
_____		
_____		

Changing from one unit of mass to another in the metric system is easily done in the same way as with linear units. Knowing the meaning of each prefix is all that is required.

1 microgram = 0.001 milligram	1 milligram = 1000 micrograms
1 milligram = 0.001 gram	1 gram = 1000 milligrams
1 kilogram = 1000 grams	1 gram = 0.001 kilogram

4. Complete the following.

   a. 750 g = _____ kg

   b. 1450 g = _____ kg

   c. 500 mg = _____ g

   d. _____ g = 2.5 kg

   e. 1450 kg = _____ g

   f. _____ μg = 0.450 mg

   g. 10 g = _____ mg

5. A patient is to be given 0.5 g of a certain medicine. If the only capsules available are in a bottle labeled 250 mg, how many capsules should the patient be given?

6. A certain drug is to be given to a patient at the rate of 5 mg for each kilogram of body mass. If the mass of the patient is 70 kg, how many mg of the drug should be administered?

7. Suppose the drug to be used in the preceding problem is in vials that have 5 mg per mL of solution. How many cm^3 will be required to obtain the dosage prescribed in the preceding problem?

8. Terramycin injection is available in 2.5 mL ampules containing 0.25 g of the drug. How many mL are needed for a 100 mg dose?

9. An order of 100 mg I.M. of demerol is ordered. If the demerol is available in a vial of 50 mg per cm^3, how many cm^3 should be administered?

10. 150 mg of Colistin powder must be dissolved in no less than 2 cm^3 of sterile water before injection. If the powder is dissolved by injecting 2 cm^3 of sterile water into the vial, the vial would contain _____ mg per 2 cm^3. How much of the dissolved Colistin would you administer if an order called for 75 mg?

Volume—Mass

One of the nice features built into the metric system is the relationship between volume and mass. For several reasons water has been used to establish this relationship: 1 dm^3 of cold water has a mass of 1 kg. (To be exact, the water should be distilled and at a temperature of 4 °Celsius.) Thus, 5 dm^3 of water has a mass of 5 kg. Furthermore, because the specific density of all other substances is related to water it is easy to find the mass of any substance if the volume of the substance is known. For example, the density of steel is 8 times that of water so 1 dm^3 of steel has a mass of 8 kg, 2 dm^3 of steel has a mass of 16 kg; alcohol is only 0.84 times as dense as water so 1 dm^3 of alcohol has a mass of 0.84 kg, 2 dm^3 of alcohol has a mass of 1.68 kg, etc.

Since 1 dm^3 = 1 liter, 1 liter of cold water has a mass of 1 kg. Also, since 1 dm^3 = 1000 cm^3 = 1 L, we see that 0.001 dm^3 = 1 cm^3 = 1 mL. So 1 cm^3 of cold water has a mass of 1 gram, and likewise, 1 mL of cold water has a mass of 1 gram. For larger volumes, observe that 1 m^3 = 1000 dm^3, so the mass of 1 m^3 of cold water is 1000 kg.

Remember that this relationship is true for cold water—not for other substances. However, 1 dm^3 of most liquids would have a mass of approximately 1 kg.

Suggested Exercises

1. 6 mL of water has a mass of 6 _____.
2. 15 g of water would have a volume of _____ mL.
3. 250 g of water has a volume of _____.
4. _____ cm = 1 dm, so _____ cm^3 = 1 dm^3.

5. _____ dm = 1 m, so _____ dm^3 = 1 m^3.

6. 1 cm^3 of cold water has a _____ g mass.

7. 1 dm^3 of cold water has a mass of _____.

8. 1 m^3 of cold water has a mass of _____ kg.

9. The water in a physical therapy tank 2 m by 1 m by 1.4 m has what mass?

10. In contrast to #9, try this one: The water in a physical therapy tank 2 yds. by 1 yd. by 1.4 yds. weighs how much?

11. A typical dose of atropine is $\frac{1}{120}$ grain, where $\frac{1}{120}$ grain is about 0.5 mg. How many doses can one give from a 30 mL vial if each mL contains 0.5 mg of the drug?

The preparation of dosages to be administered to patients usually requires some computation which takes into account the amount of drug the doctor may order and the form and strength in which the drug to be used is available. A convenient way of determining the proper dosage makes use of the following formula:

$$\text{quantity to be administered} = \frac{\text{desired dose (amt. needed)}}{\text{dose on hand (amt. on hand)}} \times \text{vehicle},$$

where the vehicle is the form of the drug, i.e., tablet, capsule, or solution. This formula can be used with either the apothecaries' or metric system of measurement.

Even though the shift to metric is becoming more prevalent, it will be common for some orders to be given in the apothecaries' system, especially in terms of grains. Such orders, however, may be easily changed to their metric equivalents by means of a few basic relationships:

1 grain $\doteq$ 0.06 gram = 60 milligrams 1/120 grain $\doteq$ 0.5 milligram

15 grains ≐ 1 gram

1/60 grain ≐ 1 milligram

1/100 grain ≐ 0.6 milligram

1/150 grain ≐ 0.4 milligram

1/200 grain ≐ 0.3 milligram

(The symbol ≐ used above means "is approximately equal to.")

Examples:

a. Suppose you have an order for 1.5 grains of Seconal and you have on hand capsules of 0.75 grain. Determine the number of capsules to be administered to the patient. The computation may be performed with apothecaries' units using the formula above but it may also be done by first changing the units to their metric equivalents. Thus the situation would be: you have an order for 90 mg of Seconal and you have on hand capsules of 45 mg each and you are to determine how many capsules should be given.

$$\frac{90 \text{ mg}}{45 \text{ mg}} \times 1 \text{ capsule} = 2 \text{ capsules.}$$

b. You have an order for ¼ grain of morphine. On hand is a vial that has 1/6 grain morphine per cm^3. What dosage should be administered?

$$\frac{15 \text{ mg}}{10 \text{ mg}} \times 1 \text{ cm}^3 = 1.5 \text{ cm}^3.$$

c. An order is for $\frac{1}{200}$ grain of atropine and you have on hand an ampule of $\frac{1}{150}$ grain per mL. What dosage should be administered?

$$\frac{0.3 \text{ mg}}{0.4 \text{ mg}} \times 1 \text{ mL} = 0.75 \text{ mL.}$$

12. Compute the dosages for each of the following.

a. On hand is $\frac{1}{6}$ grain/mL of morphine sulfate. You need to give $\frac{1}{4}$ grain.

b. From a vial of Demerol labeled 50 mg/cm^3 you are to administer 75 mg.

c. A vial contains 2 g of powder. After it is dissolved in 4 cm^3 of a saline solution you are to administer 500 mg of the drug.

d. You have 250 mg tablets of a drug on hand. The doctor orders 0.5 g.

It should be emphasized that the special volume-mass relationship in the metric system is restricted to volumes of cold water and their masses, not other substances. That is, a liter of cold water has a mass of 1 kg; a m^3 of cold water has a mass of 1000 kg; 1 milliliter of cold water has a mass of 1 gram.

To help with this understanding, the following experiment is suggested:

a. Take two containers, similarly constructed, each large enough to hold 1 liter.

b. Place the containers on opposite sides of a balance scale. Adjust the balance scale so that it balances properly. Fill one container with a liter of cold water and the other with a liter of sand. Are the scales now in balance? Does a liter of sand have a mass that is equal to, greater than, or less than a liter of cold water?

c. Repeat (b) above using a liter of salt or boric acid crystals.

d. Repeat using a liter of pop, milk or some other liquid. In these cases are the masses approximately equal to that of a liter of water?

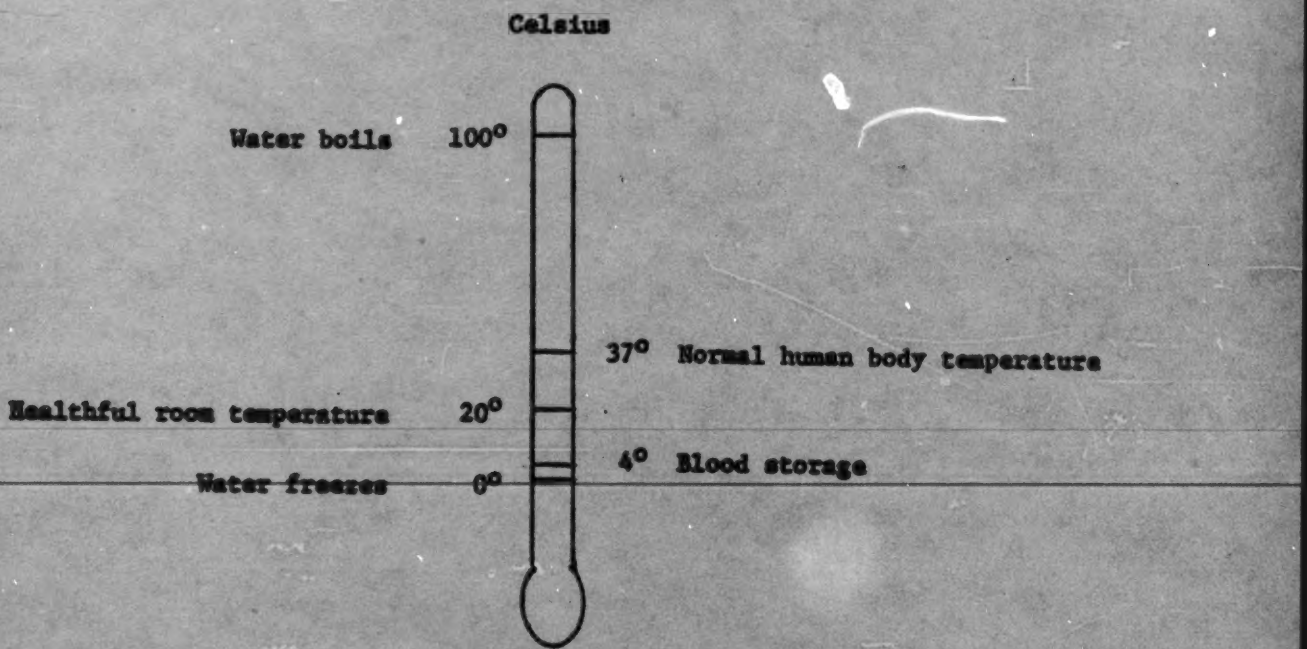
e. If the material is available, make a cube one decimeter on an edge out of cork or styrofoam. Compare the mass of this cube with that of a liter of water. (Caution: Be sure to compensate for the mass of the container holding the liter of water.)

Other Units

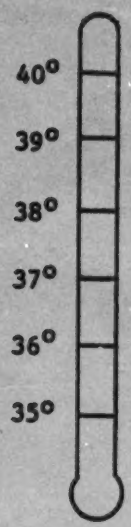
Several other metric units may be used to some extent in health occupations. A few of these are discussed here.

Temperature

The basic SI unit of temperature, the kelvin, will be used primarily in the sciences. Temperatures for most non-scientific work will be reported in degrees Celsius (°C). This is not a basic SI unit but it has been accepted for use with SI. The Celsius scale is named after the first man to use it and is identical to the centigrade scale which has been in use for many years. (The term "centigrade" which also is an inclination measurement of 0.01 of a right angle, should no longer be used for temperature measurements.) A few important reference points on the thermometer are pictured below.



In addition to knowing some of the commonplace Celsius temperature readings, medical personnel must also become familiar with that portion of the Celsius scale associated with human body temperature. Some of the pertinent temperature ranges are shown below.



Apply ice blanket and force fluids

Check temperature each 4 hours

Normal body temperature

Warm the patient

Of course, there is no such thing as an exact normal body temperature. It is just that 37 °C is approximately the average. Individual medical histories would be required in order to judge whether a temperature reading above or below 37 °C would be abnormal for that individual. Speaking in general terms, however, a temperature of 38 °C is likely to prompt further investigation to see if measures to combat this elevated temperature would be appropriate.

It is hoped that medical personnel will soon be able to think strictly in terms of Celsius temperatures and not be forced to make conversions between Celsius and Fahrenheit. A few pertinent equivalents may be easily remembered.

98.6 °F = 37 °C

100.4 °F = 38 °C

104 °F = 40 °C

These reference points, together with the fact that a change of 1.8 °F is equivalent to a change of 1 °C should be adequate for most purposes in making this change from one scale to the other. There are rules of thumb and formulas which can be used for making the conversion, but these are somewhat cumbersome and time consuming to use. Conversion scales are commercially available as well.

Force

The SI unit of force is the newton (N). One newton is the force needed to give a mass of 1 kg an acceleration of 1 meter per second per second. In symbols this is expressed as: force (N) = mass (kg) x acceleration (m/s^2),

$$1\ N = 1\ kg \cdot m/s^2.$$

The newton is used to measure the force needed to stretch a rubber band, to depress an automobile accelerator, to drag a box across the floor, to lift a baby, and to measure the force of gravity. For example, the force needed to lift an apple is about 1 newton.

In the past, scientific and other technical use has differentiated between weight and mass. At the present time however, recommendations to the International Committee for Weights and Measures, and practices initiated by the American National Metric Council (ANMC) and the National Bureau of Standards (NBS) indicate that the term weight will be avoided in scientific and other technical fields. The term force of gravity will be used instead. In everyday activities the term weight may be used synonymously with mass.

The force of gravity on an object can be approximated if its mass is known. A kilogram mass exerts a downward force on the surface on which it rests. On earth the acceleration due to gravity is about 9.8 m/s^2, so the force exerted is 1 kg x 9.8 m/s^2 or 9.8 N. Roughly then, a 1 kg mass has a force of 10 N and the gravity force on a 250 gram hamburger is about 2.5 N.

Energy-Work

The metric unit of work and energy is the joule (J). In the customary system there are several units of energy but those most commonly used are the calorie, the kilocalorie ("large" calorie), kilowatt hour, and British Thermal Unit (BTU). The calorie is used primarily as a measure of heat energy and the large calorie is used for food energy. In the metric system (SI), the joule or kilojoule will be used for all measures of energy. Since the joule is rather small, the kilojoule (kJ) and megajoule (MJ) are likely to be used.

Listed below are the energy values for average servings of several different foods.

Food	Food Energy
Salted peanuts, 50 mL	736 J
Coleslaw, 120 mL	343 J
Orange sherbet, 120 mL	540 J
Donut, cake type	523 J

Examples of energy comsumption are:

Refrigerator per day	18 MJ
Range per meal	5.4 MJ
Oven per hour	1.8 MJ
Toaster per slice	18 kJ
Iron per hour	3.6 MJ
Water heater per day	43.2 MJ
Color TV per hour	1.18 MJ
100 watt bulb per hour	360 kJ
Hair dryer per hour	1180 kJ

The energy usage of the items above is currently measured in kilowatt hours. The kilowatt hour is a measure of work which is accepted in the SI but its use

should not be extended beyond the present uses. Instead the megajoule should be used. Note that 1 kwh = 3.6 MJ.

Pressure-Stress

The SI unit for pressure (and stress) is the pascal. It is the force of one newton per square meter (N/m^2). Thus, it is a measure similar to the conventional pound per square inch (psi). The pascal is a rather small unit of pressure. Imagine that 100 mL of water was poured evenly on a surface of one square meter. The layer of water would be very thin--only about 0.1 mm. Clearly the force exerted is quite small. Consequently, the kilopascal (kPa) will be used frequently. Auto tire pressure, for example, would be about 200 kPa. Normal atmospheric pressure at sea level is about 101 Pa.

Pressure is now measured in a number of different ways in health occupations. The unit "cm of water" is used in some instances. The sphygmomanometer measures blood pressure in millimeters of mercury (mm Hg). These units will soon be replaced by the pascal. One mm Hg is approximately 133 Pa, so a systolic blood pressure of 120 would be equivalent to 15 960 Pa or 15.96 kPa. One cm of water is equivalent to 98 Pa. The bar (100 kPa) and inches of mercury (3.4 kPa) will also be discontinued.

Miscellaneous

1. The ordered dose of a certain medicine is 60 grains per day. How much of a solution labeled 2 g/4 cm^3 would be used daily?

2. A dextrose 5% solution of I.V. fluid might come in a bottle containing _____ of solution.

   a. 1 L b. 3 dm^3 c. 5 dL

3. The patient was put in _____ of traction.

   a. 60 g b. 3 kg c. 500 mg

4. If a patient's fluid intake is about 2000 mL per day, the expected output would be _____ if the patient is normal.

   a. 600 mL b. 1200 mL c. 1500 mL

5. If the patient is dehydrated, the output would be about _____.

   a. 600 mL b. 1200 mL c. 1500 mL

6. Given below is a list of containers for foods used in making an intake study for a patient. Select one of the following quantities to go with each of the items: 240 mL, 200 mL, 130 mL, 120 mL, 100 mL, 90 mL.

Item	Quantity
Milk carton	_____
Insulated coffee cup	_____
Styrofoam cup	_____
Paper juice glass (Dixie)	_____
Small glass (clear plastic)	_____
Large water glass (clear plastic)	_____
Jello	_____
Ice cream	_____
Soup bowl	_____
Custard cup	_____

7. Irrigation fluids commonly come in _____ bottles.

   a. 0.75 L b. 1500 mL c. 3000 mL

8. If the reaction to a TB test measures _____ across, the reaction is considered pure positive.

   a. 15 mm b. 3 dm c. 4 cm

9. Phenobarbitol is ordered to be given 1/4 gr. four times a day. How many mg of the drug would be administered in two days?

10. Phenobarbitol elixir is ordered 15 mg three times a day. The bottle is labeled 1 gr./cm^3. What size dose should be administered?

11. The dentist injected _____ of novocain to anesthetize the patient's tooth.

    a. 0.5 L b. 10 cm^3 c. 3.6 mL

Appendix A

The Supplementary Units

Unit	Quantity	SI Symbol
radian	plane angle	rad
steradian	solid angles	sr

The Derived Units with Special Names

Unit	Quantity	SI Symbol	Definition
newton	force	N	$m \cdot kg \cdot s^{-2}$
pascal	pressure	Pa	N/m^2
watt	power	W	J/s
joule	energy	J	N·m
coulomb	electric charge	C	A·s
farad	electric capacitance	F	C/V
henry	inductance	H	V·s/A
hertz	frequency	Hz	1/s or s^{-1}
lumen	luminous flux	lm	cd·sr
lux	illuminance	lx	lm/m^2
ohm	electrical resistance	Ω	V/A
siemen	conductance	S	A/V
tesla	magnetic flux density	T	Wb/m^2
volt	electric potential	V	W/A
weber	magnetic flux	Wb	V·s

The Derived Units without Special Names

Unit	Quantity	SI Symbol
square meter	area	m^2
cubic meter	volume	m^3
meter per second	linear velocity	m/s
radian per second	angular velocity	rad/s
meter per second squared	linear acceleration	m/s^2
radian per second squared	angular acceleration	rad/s^2
newton-meter	moment of force	N·m
kilogram per cubic meter	density	kg/m^3
joule per kelvin	entropy	J/K
watt per square meter	thermal flux density	W/m^2

Prefixes

Names of multiples of SI and metric units are formed by using a prefix with "meter", "gram", "liter", "watt", or any other unit. Symbols use a prefix letter such as "ns" for nanosecond, "kHz" for kilohertz, "mV" for millivolt, etc.

giga	G	10^9	1 000 000 000	one billion
mega	M	10^6	1 000 000	one million
kilo	k	10^3	1 000	one thousand
hecto	h	10^2	100	one hundred
deka	da	10^1	10	ten
—	—	10^0	1	one
deci	d	10^{-1}	0.1	one tenth
centi	c	10^{-2}	0.01	one hundredth
milli	m	10^{-3}	0.001	one thousandth
micro	μ	10^{-6}	0.000 001	one millionth
nano	n	10^{-9}	0.000 000 001	one billionth
pico	p	10^{-12}	0.000 000 000 001	one trillionth

Appendix B

Apothecaries' System

Weight	Liquid or Fluid
Grain	Minim
Dram	Fluidram
Ounce	Fluidounce
Pound	Pint
	Quart
	Gallon

60 grains = 1 dram	60 minims = 1 fluidram
480 grains or 8 drams = 1 ounce	480 minims or 8 dluidrams = 1 fluidounce
12 ounces = 1 pound	16 fluidounces = 1 pint
	2 pints = 1 quart
	4 quarts = 1 gallon

Household System

60 drops = 1 teaspoon (t.)

3 teaspoons = 1 tablespoon (T.)

2 tablespoons = 1 fluidounce

6 fluidounces = 1 teacup

8 fluidounces = 1 glass

Approximate Equivalents

1 minim = 1 drop = 0.06 mL

1 milliliter = 1 cubic centimeter (cm^3)

16 minims = 1 cubic centimeter

4 cubic centimeters = 1 fluidram

5 cubic centimeters = 1 teaspoon

15 cubic centimeters = 1 tablespoon

30 cubic centimeters = 1 fluidounce

180 cubic centimeters = 6 fluidounces

240 cubic centimeters = 8 fluidounces

500 cubic centimeters = 1 pint

1000 cubic centimeters = 1 quart

1 milligram = 1/60 grain

60 milligrams = 1 grain

1 grain = 0.06 gram

15 grains = 1 gram

1 ounce = 30 grams

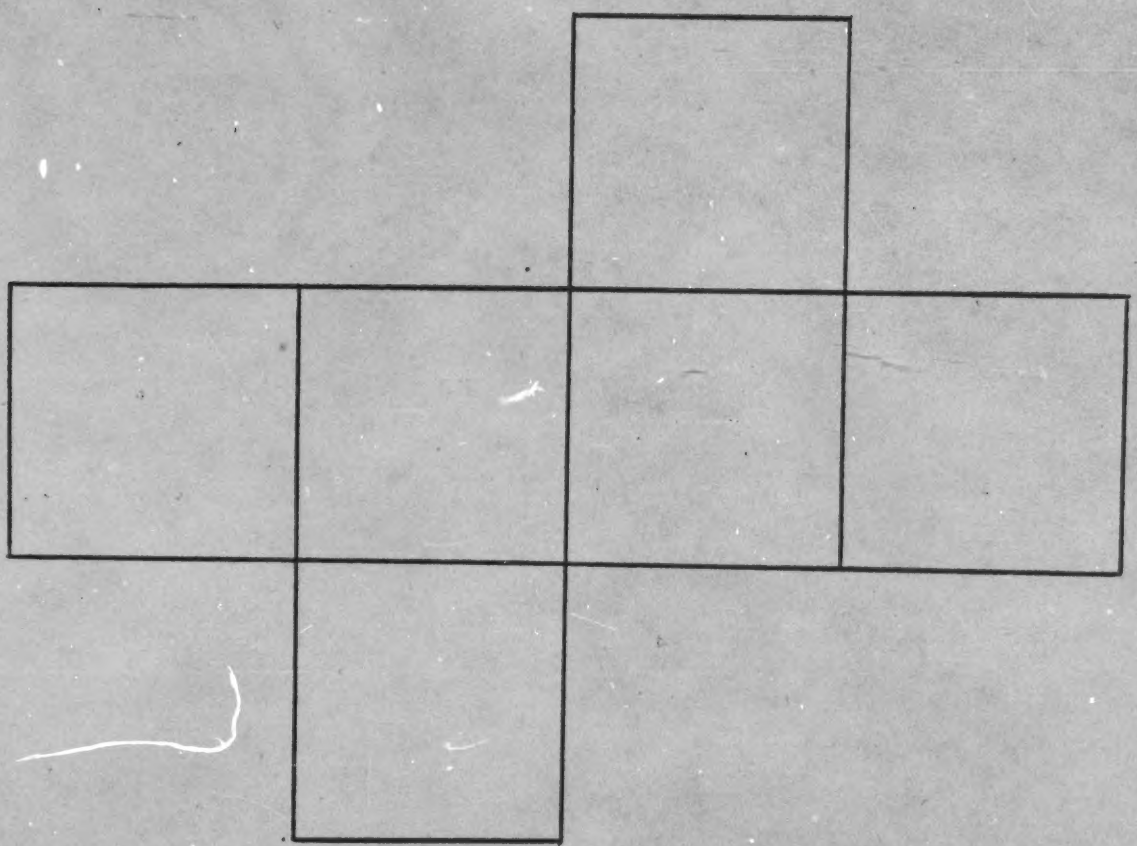
$\frac{1}{100}$ gr. = 0.6 mg

$\frac{1}{150}$ gr. = 0.4 mg

$\frac{1}{200}$ gr. = 0.3 mg

Appendix C

Suggested Diagram for Paper Cubes



Appendix D

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Appendix E

Standards Committees

ISO--The International Organization for Standards is an international, non-governmental agency for standards which is comprised of national standards bodies of about 80 nations.

ANSI--The American National Standards Institute is a federation of some 180 trade associations, technical societies, labor unions, and about 900 company members. ANSI is the U. S. member of ISO. ANSI does not write standards. It reviews and approves proposed standards written by committees administered by many technical and trade associations after all concerned groups have accepted them.

The address for ANSI is 1430 Broadway, New York, New York 10018. Current information about developments within specific trade associations is found in journals such as:

Metric News. Published bimonthly by Metric News, Inc., 830 North 109th Street, Milwaukee, Wisconsin 53226.

Metric Bulletin. Published monthly by J. J. Keller and Associates, Inc., 145 W. Wisconsin Avenue, Neenah, Wisconsin 54956.

Metric Reporter. Published biweekly by the American National Metric Council, 1625 Massachusetts Avenue, N.W., Washington, D.C. 20036.

American Metric Journal. Published bimonthly by AMJ Publishing Company, P.O. Box 696, Tarzana, California 93156.

Answers

Pages 15-16

4. a. m
   b. mm
   c. dm
   d. cm
   e. cm
   f. mm
   g. m
   h. mm

5. a. 2.5 mm
   b. 6 dm
   c. 1.4 m
   d. 6 mm
   e. 1.75 dm

6. a. 5600
   b. 5.6
   c. 3200
   d. 280
   e. 0.28
   f. 8
   g. 6.35; 635
   h. 5.8; 0.058
   i. 139
   j. $2\frac{17}{36}$; 89

7. 50

Pages 17-21

3.

Region	Calculated Area	Region	Calculated Area
1	8 cm^2	4	9.6 cm^2
2	8 cm^2	5	12.6 cm^2
3	57 cm^2		

6. a. cm^2
   b. cm^2
   c. m^2
   d. dm^2
   e. cm^2
   f. cm^2

7. a. 20 m^2
   b. 48 cm^2
   c. 28.8 m^2
   d. 209 m^2
   e. 175 000 m^2
   f. 88 920 m^2

8. a. 7400
   b. 60 000
   c. 1050
   d. 616
   e. 21
   f. 0.295
   g. 4.062 5
   h. 60

9. a. 30 000
   b. 0.50
   c. 500
   d. 2.5
   e. 4

10. 3.6

11. 11 200; 112

12. 2.7

13. 14.86 or about 15

Pages 23-24

3. a. cm^3
   b. dm^3
   c. cm^3
   d. m^3
   e. m^3
   f. mm^3
   g. cm^3

4. a. 2000
   b. 0.5
   c. 0.004
   d. 4
   e. 420
   f. 1491
   g. 102.4
   h. 0.186 321
   i. 144 000
   j. 0.144

5. 1.5

6. 3000 cm^3

7. Yes, the volume of the room is 57.6 m^3.

8. 0.15; 150

Pages 26–29

2. a. mL
   b. mL
   c. mL; mL; mL
   d. mL
   e. mL
   f. mL
   g. L
   h. L
   i. mL
   j. mL
   k. mL
   l. mL

3. a. 15 mL
   b. µL
   c. dL

4. a. 1000
   b. 2
   c. 5
   d. 20
   e. 250
   f. 4000
   g. 10 000
   h. L
   i. 1
   j. 250
   k. 2500

5. 100

6. $\frac{2}{3}$

7. 18; 5; 259; 18; 0.0015; 300; 70 cm^3; 70

8. 3; 1

9. no; no

10. yes; 100

11. 10

Pages 31-33

1. a. g
   b. g
   c. g
   d. mg
   e. mg
   f. mg; g
   g. mg
   h. µg

2. 100 mg

4. a. 0.750
   b. 1.450
   c. 0.5
   d. 2500
   e. 1 450 000
   f. 450
   g. 10 000

5. 2

6. 350

7. 70

8. 1

9. 2

10. 150; 1 cm^3

Pages 34-36

1. g

2. 15

3. 250 mL

4. 10; 1000

5. 10; 1000

6. 1

7. 1 kg

8. 1000

9. 2800 kg

10. V = (2 x 1 x 1.4) $yd.^3$ = 2.8 $yd.^3$ = (2.8 x 27) $ft.^3$ = 75.6 $ft.^3$.
Since 1 $ft.^3$ of water weighs about 62.5 lb., 75.6 $ft.^3$ of water weighs about (75.6 x 62.5) lb. = 4725 lb.

11. 30

12. a. 1.5 mL
b. 1.5 cm^3
c. 1 cm^3
d. 2 tablets

Pages 43-44

1. 8 cm^3

2. 1 L

3. 3 kg

4. 1500 mL

5. 1200 mL

6. 240 mL; 240 mL; 200 mL; 100 mL; 100 mL; 200 mL; 90 mL; 120 mL; 130 mL; 90 mL

7. 1500 mL

8. 4 cm

9. 120

10. 0.25 cm^3

11. 3.6 mL